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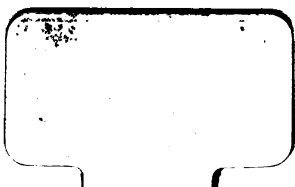
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TOPOGRAPHICAL MEMOIR.

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MEMOIR

UPON

THE TOPOGRAPHICAL SYSTEM

OF

COLONEL VAN GORKUM,

WITH REMARKS AND REFLECTIONS UPON VARIOUS OTHER
METHODS OF REPRESENTING GROUND:

ADDRESSED TO

LT. GEN. SIR HERBERT TAYLOR, G.C.H.

SURVEYOR-GENERAL OF HIS MAJESTY'S ORDNANCE.

BY

M. GEN. SIR JAMES CARMICHAEL-SMYTH, Bt.

C.B. K.M.T. K.S.W.

“Some even of those who are employed in the administration of states, or placed at the head of armies, imagine that an unequal and hilly ground will contain more houses, than a surface which is flat and level. This, however, is not the truth. For the houses being raised in a perpendicular line, form right angles, not with the declivity of the ground, but with the flat surface, which lies below, and upon which the hills themselves also stand.”—*Polybius*.

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TO
LT. GEN. SIR HERBERT TAYLOR, G.C.H.
&c. &c. &c.

MY DEAR SIR HERBERT,

IF the system for showing the height of hills, and the nature of their slopes, which I have endeavoured to explain in the following pages, shall be found useful, and be adopted in His Majesty's Service, the merit of its introduction may be in a great measure attributed to you. It was the circumstance of your sending to me Lieutenant Siborn's translation of Major Lehman's work on Topography, which led me to mention to you the superiority of the mode of expressing the features of ground invented by Colonel

Van Gorkum. His Royal Highness the Duke of York, constantly alive to whatever could benefit the King's Service, was subsequently induced to send two officers to the Netherlands to become acquainted with that system in its details. From the papers of these gentlemen, and from the instructions they received from Colonel Van Gorkum, I have extracted and culled with care as much of the System as appears to me to be applicable to His Majesty's Service; and by the adoption of which we shall be enabled to show, in our military plans, with accuracy and expedition, the height of all hills, and the nature of all slopes. Our drawings will in future be, in fact, legible; an inappreciable advantage of which they are at present nearly destitute.

As it is by means of your assistance,

and by your cordial co-operation, that I have been enabled to proceed so far in making the subject known to the British Army, it is to you I wish to offer the following pages in testimony of that most sincere esteem and regard with which

I am,

My dear Sir Herbert,

Yours, most faithfully
and truly,

JAMES CARMICHAEL-SMYTH.

NUTWOOD, REIGATE,
25th March, 1828.

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MEMOIR,

&c. &c.

I.—NOTWITHSTANDING the many modern improvements in military science; the capability of expressing the features of ground, in a clear and decided manner, by rule, and upon principle, so as to leave but little to the taste, the imagination, or the fancy of the draftsman, is still, in the British service, a desideratum. It seems hardly necessary to expatiate upon the very great importance of some fixed rules, if a perfect system cannot be contrived. Without a section or a view, it is impossible, from the inspection of any map or plan, as at present drawn, however accu-

rate in regard to the distances and the relative situations of objects, to form a decided idea as to the nature of the country. One draftsman will shade lightly slopes, which to another may appear ought to be expressed more strongly; and the general who is to direct movements, and to combine operations, has to explore his way with very unsatisfactory and insufficient materials.

II.—The German and the French military have been long aware of the inconveniences of the want of a system, and repeated endeavours have been made by able and scientific men of both nations to remedy the evil. Major Lehman, of the Saxon service, is the author of a very ingenious method of showing the inequalities of ground, and of exhibiting the nature of the different slopes. His System, with

some little modifications, has been adopted in the Prussian, Saxon, Bavarian, and Austrian armies. The Major has done away (in his mode of drawing ground) with the established usage of supposing the rays of light to be admitted at the left hand upper corner of the plan. Light is admitted in parallel vertical rays from above; and, upon this idea, the quantity of light, and of shade, which each slope upon the ground would actually show, according to its angle with the horizon, has been calculated. Upon these data, a scale has been prepared; by which all changes of slopes, and the nature of all acclivities, from 5° to 45° , can be exhibited at 5° interval.

III.—The objections to Major Lehman's system, are not only the labour and extreme attention required of the draftsman, who has nine different scales to refer to,

to regulate the contiguity of the strokes he is to make with his pen, according to the more or less abrupt nature of the slope he is about to represent; but after all his pains and labour, the information to be acquired from an inspection of the plan is very incomplete. In the first place, Major Lehman makes no difference between a slope, at an angle of 45° , and precipitous rocks; between difficulties which can be got over, and obstacles insurmountable in their nature. In the next place, neither the heights of the hills themselves, nor their relative altitudes, are clearly shown. It is very true, that by measuring the length of a slope with a pair of compasses, and learning, from an inspection of the scale, the angle it makes with the horizon, the rules of plane trigonometry will give the perpendicular. This is, however, a calculation, for which there may

not always be sufficient time. By inventing a method of showing the nature of the slopes, Major Lehman unquestionably advanced our topographical knowledge one step, and that a very important one. It is evident, however, that much yet remained to be done, before a perfect system could be said to be proposed.

IV.—A great deal has been written and published in France, as to the mode in which light ought to be admitted, and as to the greater or less accuracy or fidelity of representation to be obtained from vertical or angular rays. Committees of men of science have been expressly formed by order of the Government, with a view to the determining of the question, and of coming to a correct decision with respect to it. The celebrated mathematician, La Place, was the president of one, which has

already sat for some time, but without being able to come to any result. The engraving of the grand new map of France is suspended, until the manner in which the ground is to be expressed shall have been maturely considered and decided upon.

V.—In addition to the diversity of opinions in France, as to the mode of admitting light upon their plans, the French engineers are by no means unanimous as to the best method of either sketching or expressing ground, and this subject has also undergone many discussions. The plan which has been generally adopted, (and by authority,) has been, at every ten metres of difference of level to sketch the contour or shape of the hill. These different concentric figures would, of course, be each the horizontal outline of the ground at its own level, and the base

of the higher part of the surface above it. Straight lines were drawn to connect these different levels, which lines representing the horizontal distances between them, were of course longer or shorter according to the abrupt or easy nature of the slope. Whatever their length was, there was thus a right-angled triangle, the length of two sides of which were known. From these data, the value of the angle subtended by the base or normal, as well as that formed by the normal and the hypotenuse, were easily to be obtained. There was, consequently, no difficulty in forming a scale, which, according to the length of the normal, would give the angle it formed with the hypotenuse; or, in other words, the angle of the slope. By the construction of a plan upon these principles, the French had, it would appear, made a rapid advance in topography. By counting the normals,

and multiplying the number by ten, or any other number of metres at which the equidistant horizontal levels had been taken, the height of any ground in the plan was ascertained; and by measuring any of the normals with a pair of compasses, and applying them to the scale, the nature of the slope, or the angle it made with the horizon, was known. Two very essential and important points for all military purposes, were thus obtained. The system could not, however, be said to be complete. An important military feature might be situated between two of the equidistant horizontal levels; one of the horizontal levels might have to be taken in the middle of an important and continuous slope; features might not only thus be overlooked, but false features might be introduced. In many situations, there must be difficulties, not to be overcome, in the way of carrying

a level completely round a hill. The great objection was, however, with respect to the normals themselves. It is evident, that in order to be able to show upon paper the base of a right-angled triangle subtending a very acute angle upon the same scale as the base of a right angled triangle subtending nearly a right angle, the latter base or normal must be drawn upon a very large scale. This difficulty the French have not been able to get the better of. They cannot express, by their system, any slope steeper than 25° , without having the normals for the lower angles at a very inconvenient length; and this is an additional reason for the suspension of the engraving of the new Map of France, already alluded to.

VI.—Colonel Van Gorkum, of the Netherlands' Army, has within a few years

invented and perfected a system which obviates every difficulty, and is certainly a most complete, and most elaborate attempt to reduce every thing connected with topographical drawing to rule. No fault can be found with Colonel Van Gorkum's system. It is perfect in all its details. A plan drawn upon Colonel Van Gorkum's method, is unquestionably the next best thing to a model of the ground. Notwithstanding, however, my decided opinion as to the merits of this system, the details of which, being founded upon mathematical principles, are all susceptible of demonstration; I do not think it is calculated for general use, or that it ought to be, *in toto*, adopted in our service. I do not think it is suited to our national character, or, that either officers or surveyors could ever be brought, with us, to pay that unremitting attention (in drawing) to the length,

thickness, and contiguity of their lines, upon the accuracy of which the system depends. It occurs to me that his Majesty's service will be very materially benefited by a partial adoption of some of the details: and which (if engrafted upon the mode at present employed by our engineers and military surveyors) will give to the British army a facility for ascertaining and expressing the height of all hills, and the nature of all slopes, whenever one or the other may be of importance, with accuracy and expedition. Any thing beyond this, in plan-drawing, appears (however beautiful and correct in theory) only a waste of time in actual practice.

VII.—In Colonel Van Gorkum's method the shape of the hill is to be sketched, as in that of the French, at certain fixed and equidistant levels; and the length of the normal is to show, by reference to the scale,

the slope of the hill. A good deal of ingenuity and of previous arrangement has been manifested in determining the heights of the perpendiculars, which have been calculated according to the different scales generally made use of, so as to allow the normal not to be too short when it has to subtend an acute angle, nor too long when the angle is nearly a right angle. At the scale of four inches to one mile, (the one generally adopted in military sketching in the English service,) which answers to the proportion of 1 to 15,840, the perpendicular is fixed at twenty-four feet, and which will allow the normals to express, with tolerable facility to the draftsman, all angles up to 25° . This is the difficulty, as already explained, which the French have not been able to get the better of. To obviate the inconvenience of the very short normals at the higher angles, they

have discovered no remedy but that of extending the normal to a very inconvenient length at the lower angles. Colonel Van Gorkum has, however, removed all impediments; and slopes of an abrupt nature, and even at an angle of 75° , can be expressed, according to his system, with almost the same facility as those of 10° or 15° . This is accomplished by doubling, tripling, or even further augmenting, as the case may require it, the perpendicular. If, for instance, ground was to be drawn at the scale of four inches to a mile, the horizontal levels being at a perpendicular height of twenty-four feet above each other, and a slope of 45° was to be expressed, the normal of 45° , with a perpendicular of twenty-four feet, would, at such a scale, be too small to be distinctly represented. In that case Colonel Van Gorkum would take his next horizontal level at forty-eight feet,

which operation, while it augmented the perpendicular height of the right-angled triangle, would, of course, afford a corresponding proportional length to the normal. When it is found necessary at the higher angles thus to change the distance of the horizontal levels, Colonel Van Gorkum has adopted the plan (to prevent any mistakes) of causing the normals of the extended perpendicular to be represented with thicker lines, and nearer to each other, in order that it may be seen at once (upon reference to the scale) that in counting the normals to ascertain the height of the ground, these thicker and closer ones are to be reckoned at double or triple the distance of the lower levels, as the case may be. By this method it is evident that, without making his normals, at the lower angles, of an inconvenient or unnecessary length, Colonel Van Gorkum can show the

base or normal of any right-angled triangle, whatever the angle formed by the normal and the hypotenuse may be. His perpendiculars being radii, and his normals co-tangents, it is evident the same relative proportion must be always preserved between them; and that consequently the measurement of the normal, whether the perpendicular may or may not have been augmented, will equally give the value of the angle required. This is a most ingenious and happy application of mathematical principles to the advancement of topographical science, and reflects the greatest credit upon Colonel Van Gorkum's talents and ingenuity.

VIII.—It is hoped that the foregoing precis, or explanation of Colonel Van Gorkum's system, will be found sufficiently clear without entering into further details. It may be necessary to add, that as all hills

and irregularities of ground are shown strictly upon ichnographical principles, light is supposed to be admitted in parallel vertical rays.

IX.—From what has been said, it would appear that Colonel Van Gorkum has very materially benefited the art of plan-drawing, as well as topographical science in general. His system, as I before observed, may indeed be said to be perfect. I have already explained why, notwithstanding its merits, I do not think its adoption, *in toto*, in the British service desirable. I will now point out what parts may, in my opinion, be omitted, and what, as it appears to me, be adopted with advantage. To enable me to form my judgment, and being duly impressed with the full importance of the subject to the King's service, I have not only read Colonel Van Gorkum's papers with every attention, but I have pe-

rused the printed topographical memoirs and the proceedings of the French commissions; as well as the recent pamphlets of Lieutenant Colonel Puissant, director of the French Topographical Dépôt, and that of the French general of engineers, Haxo. Without entering into their various reasons for and against the use of horizontal levels in surveying; in favour, on the one hand, of ichnographical, or, on the other, of perspective representations of hills; or repeating their conflicting opinions as to the propriety of the admission of the rays of light vertically, or from the left-hand upper corner of the plan, I will submit the result of their arguments, and the conviction the best consideration of the subject has conveyed to my mind of what will be most advantageous to his Majesty's service.

X.—On account of the objections, as stated in paragraph V., I am decidedly

against the use of the equidistant horizontal levels forming concentric figures subsequently connected by straight lines; and I am of opinion, that the rays of light ought not to be vertical, but be admitted, as at present, from the left-hand upper corner of the plan or drawing. In rejecting the horizontal levels, I would, however, propose that we should retain so much of the system of normals as will enable us to show the nature and angles of the slopes, and the height of the hills, both positively and relatively. By adopting this measure, (which I will explain in the ensuing paragraphs may easily be done, and with very little additional trouble to the person actually surveying from that which he is at present obliged to take,) a very great and material improvement would be introduced into our service. By retaining our mode of admitting light upon the plan, the drafts-

man, having moreover his hand assisted and directed by the introduction of the normals, will be able to describe the ground as beautifully, but more correctly, than at present. Vertical rays can only be admitted in a completely ichnographical plan, the construction of which is, I humbly conceive, a work of more labour and minute attention than can often be required for any practical purpose.

XI.—In order that I may be able more readily to explain the mode in which I propose to apply the system, and that the reader may with the greater facility perceive its advantages, I will proceed, in the first instance, to demonstrate the theory of the construction of the normals, both with the single and with the augmented perpendicular. I will subsequently show how these normals are to be projected. The ac-

curacy of the information to be obtained, and the facility of communicating it afforded by the normal system, will astonish those who have not turned their minds to such subjects.

XII.—The normal system is founded upon the immutable properties of the right-angled triangle; in which, if we know the length of the perpendicular and of the base, we have two sides and the contained angle given to us to enable us to find the value of the remaining angle and of the hypotenuse. In a right-angled triangle, moreover, if we subtract the contents of either of the acute angles from 90° , we shall have the value of the remaining angle.

XIII.—Diagram No. 1, Plate No. 1, will explain the theory upon which these simple, but incontrovertible, truths have

been made available to show the nature of the slopes of all hills, whatever may be their acclivity. ABC , ABD , ABE , ABF , ABG , are right-angled triangles, having one common perpendicular, AB , the length of which is known. BG , BF , BE , BD , and BC are the normals respectively of the angles of elevation BGA , BFA , BEA , BDA , and BCA . When projected upon a plan, they severally represent the hypotenuses AG , AF , AE , AD and AC ; and their lengths being measured and referred to the normal scale, prepared for the purpose, they will show the angle that each hypotenuse, to which they individually have reference, makes with themselves; or, in other words, the nature of the slope. We are thus enabled to describe, by a series of normals, the elevation of the ground with precision, and to any extent which may be required.

XIV.—When the slope to be represented is of a more abrupt or bolder nature, and the angles of elevation (as shown at BCA and BDA) are less acute, the normals BD and BC would become too small to be conveniently expressed or accurately measured. This was the obstacle which, as explained in paragraph V, for a length of time prevented the general use of the normal system. By however doubling the perpendicular, as recommended by Colonel van Gorkum, this difficulty is removed. In diagram No. 1, AH is the new perpendicular, double of AB , which is assumed to overcome the inconvenience in question. As the perpendicular AH is only a prolongation of the radius AB , the normals HK and HI are co-tangents to arcs of the same value as those to which the normals BD and BC are co-tangents. We know

that the angles of elevation HKA and HIA , are of the same nature as the angles of elevation BDA and BCA , because if two angles in a triangle are equal to two angles in another triangle, the third angle will also be equal, and the triangles be equiangular; and in the right-angled triangles AHK and ABD , we have not only the right angles, but also the angles at the vertex the same. The same may be said of the triangles AHI and ABC . And as equiangular triangles have their sides proportional, it follows that the normals HK and HI bear the same proportion to their respective hypotenuses KA and IA , as the normals BD and BC (which they are meant to supersede) do to their hypotenuses DA and CA .

XV.—In measuring the new normals, thus acquired by doubling the perpen-

dicular, mistakes might happen if we depended only upon their length. To avoid any inconvenience of this sort, I propose to adopt as a distinguishing mark, as will be seen upon the normal scales attached to this little volume, a double line when the perpendicular has been doubled; a triple line whenever it has been necessary to triple it; and so on as often as it may be required to augment the perpendicular. I conceive this plan to be the most simple and the clearest method of showing the alterations of the perpendicular, and the least liable to error.

XVI.—Diagram No. 2, Plate 1, is a scale of normals projected upon the principles as explained in the two preceding paragraphs. In constructing this scale I have taken the fortieth of an inch as the perpendicular. I have assumed, as a rule,

that no normal (except those for the very highest angles and which are seldom required) should be less than the tenth of an inch. Anything smaller can neither be measured with accuracy or be read with convenience. Colonel Van Gorkum begins with the fifty-fifth of an inch, which, although affording the advantage of a shorter perpendicular, and of being able in consequence to show smaller features at the lower angles, yet would require (if my idea of having no normal less than the tenth of an inch in length is adopted) the perpendicular to be so soon doubled that this benefit would be lost immediately. After several trials I ascertained that the fortieth of an inch is the length of perpendicular best adapted for our scales, and for the partial mode in which I propose to make use of the system.

XVII.—The normals are immutable. Whatever may be the scale at which the plan is to be drawn, the same normal will show the same angle of the slope of the ground. The value of the perpendicular, however, has reference to the scale. The perpendicular I have proposed, as already explained, is the fortieth of an inch, and of course will be to be estimated according to the proportion the fortieth of an inch bears to the number of inches to the mile at which the surveyor may be drawing. The fortieth of an inch, at six inches to the mile, is twenty-two feet; at four inches to the mile thirty-three feet; at two inches sixty-six feet; at one inch 132 feet. These numbers, of course, are the value of the perpendiculars at the different scales to which they refer.

XVIII.—Although the length of the

normal is fixed and invariable, and will always represent the same angle, whatever may be the size of the drawing, yet its value, (considered as a line marking the horizontal distance between two objects,) must, of course, vary according to the scale of the plan. A table has been calculated, and is attached to this volume, showing the value of the perpendicular, of the normal, and of the hypotenuse, (or, in other words, the extent of slope of ground represented by the normal,) at the various degrees from 1° to 75° ; and at the four scales principally used in the British service either for sketching or for engraving. This table will be found very convenient by officers and others making use of the normal system.

XIX.—Plate No. 2 shows the facility afforded by the normals, of making a sec-

tion without the necessity of going upon the ground. Any person, without even being in possession of a normal scale, can make a section from a plan on which the normals have been projected in a few minutes. The advantages of being enabled thus to read a plan are too obvious to be enlarged upon. I do not know that the plate requires any explanation. The diagrams are, I conceive, sufficiently clear and explicit. The only thing which the reader will not immediately comprehend is the broken or dotted normal in Figure 1. In a subsequent paragraph, the subject of broken normals will be entered upon. At present it need only be stated, that this normal indicates a height of 22 feet, and an angle of 30° , as may be seen by reference to the section beneath it.

XX.—Plate No. 3 is the reverse of the

preceding plate; and as Plate No. 2 explains how a section can be formed from the normals, this plate is meant to show how the normals can be procured from a section. In reducing a plan to a smaller scale, the knowledge to be acquired from an inspection of Plate No. 3 will be found useful. The normals themselves, as has already been stated in paragraph XVII., never alter; and the same normal is always to convey an indication of the same angle, whatever may be the scale of the plan. It is, however, evident, that if we are drawing at the scale of six inches to the mile, and with a perpendicular for our normals of only 22 feet, the sections to be obtained from such a scale will be more in detail, than if our plan was at the scale of two inches to a mile, and the perpendicular, for our normals, 66 feet. When therefore it is required to reduce a plan at the scale of

six inches to a mile, to a scale of two inches to a mile, or to any other scale, a new series of normals must be projected; which will be obtained by constructing sections from the normals upon the plan already existing, and forming the triangles with the enlarged perpendicular, as shown in Figure 1, Plate No. 3. The angles thus obtained by the intersection with the hypotenuse of a line, drawn at right angles to the new perpendicular, and from its lower extremity, are the angles, the normals of which are to be projected upon the reduced plan, instead of the former one. The normals themselves do not alter; but as the detailed features, which can be exhibited with a large scale, cannot be shown with a small scale, a new series of normals becomes requisite whenever a plan is to be diminished; the angles for which normals must be obtained in the

manner I have described; the normals themselves by reference to the normal scale.

XXI.—With reference to the preceding paragraph Plate No. 4 has been constructed, an inspection of which will show the same section expressed by the normal system at four different scales. The general result, with the small as well as with the larger scales, (on a height of 310 feet,) is, it will be observed, as accurate as could be wished; although, of course, the larger the scale the more detailed the information.

XXII.—As I presume my reader is now sufficiently acquainted with the theory of the normals, and made aware of their advantages, I beg to refer him to Plate No. 5, which is a survey of some ground in the neighbourhood of Reigate, at the scale

of six inches to a mile, and on which the normals have been projected in the manner I propose to make use of them. The high ground is that part of the Hog's Back called Gatton Ridge; the height and the nature of which we will suppose we are desirous to know. Three triple normals, one double and one single, form the series of normals projected upon the most western part of the ridge, affording a total of twelve normals. The perpendicular at the scale of six inches to a mile is 22 feet; so that 12×22 ought to give us the height of the ridge. One third of the lowest triple normal, it will be observed, is, however, dotted. This is meant to imply that we must deduct one-third of the perpendicular of that normal, as will be explained at length in the paragraph about broken normals. The perpendicular of a triple normal being three times the value of a

single normal, it is, in the present case, 66 feet; one-third of which, or 22 feet, must be deducted from the result we will acquire by multiplying the number of normals by the value of the perpendicular. $22 \times 12 - 22 = 242$. 242 feet is consequently the height of the point in question.

XXIII.—It may be remarked, that the information of the height of the hill, although very important, is not sufficient for military purposes; and that, in common plans, it is frequently afforded by figures. By, however, taking the lengths of the normals in our compasses, and applying them to the normal scale, we ascertain that the lowest part of the ridge is at an angle of 25° ; that the middle part is at 13° ; and that the higher part of the hill is at 5° only. By referring to the Table, at the end of this volume, for the value of the hypothe-

nuse, according to the nature of the angle, and the length of perpendicular, we shall find, moreover, in addition, the exact extent or length of each slope. We have two and two-thirds of a normal at 26° . The value of the hypotenuse of 26° we are informed by the Table is 150.5 feet at the scale of six inches to the mile. The length of the slope at that angle must consequently be twice and two-thirds that number, or 401 feet. We have only one normal at 13° , the hypotenuse of which, in the Table, is stated to be 195.2 feet, which is consequently the length of slope at that angle. The normal at 5° shows that the extent of the upper slope is 252.4 feet. I am not aware that more satisfactory or complete information can be required, or be even wished for.

XXIV.—As it may be supposed that the

normal system can only be applied to strong features and a very hilly country, I have caused a series of normals to be projected from the base of Gatton Ridge, across the country beneath it, as shown in Plate No. 5 (at the foot of the eighth series of normals on the slope of the ridge). The reader will observe that there are here five normals of 3° each, which indicate but a very gentle and continuous slope. The five normals show, however, at 22 feet each, a difference of level of 110 feet in the whole extent of 699 yards, and 2 feet, which is the length of ground between the base of Gatton Ridge and the farm-house, near which they terminate. Wherever there is a difference of level equal to the amount of the perpendicular, the normal system is applicable. In fact, it will show fractional parts of the perpendicular, as shall be explained when we come to the paragraph about broken normals.

XXV.—In Plate No. 5 there is one very long series of normals projected from the eastern part of Gatton Ridge across the valley beneath, and showing not only great diversity of ground, but slopes meeting each other from opposite heights. Although I should hope that most officers will, from what has been already said, be able to read these normals, yet as it is my anxious wish to make every thing as clear and intelligible as possible, I will, at the risk of being thought prolix, go over and explain this series, in addition to what has been previously stated upon the subject. The normals in question are upon the right or the eastern side of the plan.

XXVI.—Commencing at the top of Gatton Ridge we find one normal of 7° , and then a triple normal at 26° . From the top of the hill to the spot indicated by the

lower end of the triple normal, there is consequently a difference of level of four times 22 or 88 feet; we then find a perfectly level piece of ground without any normal. The double normal of 18° shows that for 44 feet difference of level the ground is at an angle of 18° . We have now a triple normal at 30° , which indicates the nature of the slope for the three perpendiculars or 66 feet. Two double normals, of 22° each, show that (for four perpendiculars or for 88 feet difference of level) the ground forms an angle of 22° with the horizon. We have now one normal at 10° , and one at 4° , expressing the nature of the slope to be at those angles, during the difference of level of one perpendicular of 22 feet, for each of these dimensions. The next is a broken normal. To ascertain the nature of a broken normal, the dotted line at the lower end, and in continuation of

the normal, must be measured with the normal, but one-half, one-third, or two-thirds of the value of the perpendicular (according to the proportion the dotted line may bear to the remainder of the normal) must be deducted in estimating the difference of level. In measuring the normal in question by this rule, we find it to be a normal of 2° , but only in length one-third of what it ought to be; we allow it, consequently, only one third of the value of its perpendicular: one-third of 22 feet is a little more than 7 feet. There is consequently only a difference of level of about seven feet from the commencement to the termination of this normal. The slope ends with the line part of the normal; the dotted part being only added to show its nature.

XXVII.—In the preceding paragraph I

have explained the series of normals from the top of Gatton Ridge to where the ground is met by a slope in a contrary direction. As in the broken normals the dotted parts are always at the lower end, we are made acquainted, in the present instance, from an inspection of the normal series, that the slope changes from our being met by the dotted end of a broken normal in a contrary direction. As this is, however, a fortuitous circumstance, which might not again occur, I felt very much obliged to a friend (to whom I was explaining the system) for his suggestion, that the upper part of the normals should be barbed. I immediately adopted this idea, as it prevents the possibility of any mistake. It is very true that by referring to the water courses; by considering the nature of the ground; and by causing series of normals, like radii, to be projected from

the commanding points or situations, mistakes would seldom happen; but yet there was a possibility of error. The barb at the superior end of the normal, as exhibited in the plates, certainly makes the system more perfect and complete.

XXVIII.—At the termination of the slope, (as explained in paragraph XXVI.,) we meet with a broken normal of 6° , equal to one-third of a normal of that length, but sloping in a contrary direction. For this broken normal we must allow 7 feet difference of level. We have next a whole normal of 8° , which gives a difference of level of 22 feet. At this point the barb on the broken normal, which comes next, shows, that the ground falls to the southward, as before. The broken normal is a normal of 3° , and the two radii to the westward are of 4° each. This point is

therefore only raised the value of one perpendicular, or 22 feet, above the neighbouring country; and as one-third of the broken normal is dotted, it shows that on that side of the hill one-third of the value of the perpendicular is to be deducted from the normal in the series. This point is consequently not more than 14 feet higher than the bottom of the slope, whilst the next normal shows in a contrary direction. This normal is a half one of 6° , followed by three others of 6° each, and which point out that for the extent of 736 feet, the ground falls 77 feet. The continuation of the series exhibits three normals of the same value, but in a contrary direction; and as from this hill there are two more series of normals projected, each of three in number and of the same nature, (namely of 6° each,) we ascertain that this point is a gentle eminence about

66 feet higher than the surrounding country. We now meet with a long normal of one degree and a quarter, but indicating that the slope is from the southward; and as from the point from whence this normal has been projected there are two other radii of two normals of 2° each, we know that the point in question is, on one side, about 30 feet, and, on the others, 44 feet higher than the surrounding country.

XXIX.—Plate No. 6 is a skeleton plan of the normals as projected over the survey contained in Plate No. 5. The series of normals which I have endeavoured, in the preceding paragraph, to explain, is that marked H O P M. If I have succeeded in making myself clearly understood by my reader, he will be able to ascertain the difference of level between the points M and O, between O and P

and between P and M, without any further instruction. I will, however, shortly recapitulate the levels, without again entering into the nature of the slopes.

XXX.—The hill, the summit of which is at H, is expressed by three single normals; three double normals; two triple normals and one-third of a single normal, making fifteen and one-third perpendiculars at 22 feet each, affording a total of 330 feet for the height of the point H of the Gatton Ridge. The point O is one perpendicular and one-third of another (or, in all, 29 feet) above the termination of the slope H. If 29 feet are deducted from 330 feet, we will have 301 feet left for the difference of level between the points H and O.

From the point O we have two-thirds

of one normal only, or 14 feet, to deduct from the three normals and a half normal shown on the plan as projected from P, and meeting the base of the slope of O. The perpendiculars of three normals and one half normal amount to 77, from which number if we deduct 14, 63 feet will remain as the difference of level between the points O and P; or rather as the height of command which the ground at P has over the ground at O. From P there are three normals projected towards M, the perpendiculars of which amount to 66 feet. From this amount we are to deduct about 30 feet, being the value of the perpendicular of the normal of one degree and a quarter which meets them from M. We have thus 36 feet for the difference of level between the points P and M, or for the amount of the height of the ground at P, above the ground at M.

XXXI.—The value of the information we can thus acquire from the inspection of a plan on which the normals have been constructed, is too self-evident to require any thing more to be said upon that head. It only remains for me to explain how they are practically to be projected, and to prove that my assertion in paragraph X., as to the very little additional trouble which will be required from the person surveying, should he be called upon to show the heights and slopes by the normal system, was not made in a hurry or without due consideration. The advantages of the system are great and manifest, and they are fortunately to be acquired without any inconvenience or loss of time worth mentioning.

XXXII.—In diagram No. 2, Plate No. 1, will be found (as already explained in

paragraph No. XVI.) the normal scale, which I have caused to be prepared with a perpendicular of one fortieth of an inch. Messrs. Worthington and Allan, mathematical instrument makers in Piccadilly, have, under my directions, constructed several of these scales both upon brass and ivory. The whole of the apparatus required for the introduction and use of the normal system is one of these scales. Every officer intending to use the normal system, must have a scale of normals, but that is all. He will find it convenient to have a copy of the table of the value of the normals as attached to this little volume, but that is not an indispensable requisite. A brass or an ivory scale he can hardly do without. All that I propose is, that when taking the requisite horizontal angles, the officer should be instructed further to take the angles of depression; to note them in

his field-book; and to project, upon his plan, from his normal scale, the normals answering to those angles. Nothing can be more simple or easy, and yet the advantages to be acquired by this facile operation are, to military men, immense. I understand that the young men, instructed by Mr. Dawson, are already in the habits of taking the angles of depression, to enable them to shade with more accuracy and upon principle. If they are provided with normal scales, they will consequently find all their additional trouble to consist in laying down the normals from the scale.

XXXIII.—In several of the preceding paragraphs I have alluded to broken normals. It must frequently happen that the height of a hill will not divide by the number of feet in the perpendicular of the scale at which we are drawing. A hill,

for instance, of 100 feet high will not give 5 normals with perpendiculars of 22 feet each. Four perpendiculars of 22 feet each will be 88 feet, and 12 feet will remain over. It is evident, that whatever may be the slope of this hill, and whatever may be the length of the normals indicative of that slope, the number of the normals having 22 feet perpendicular each, must be four and a half. If the half normal was however to be laid down upon the plan of the exact length of horizontal distance it is meant to represent, a false feature would be introduced. In measuring the half normal, and referring to the normal scale, it would appear, without some further explanation, that we had an abrupt slope, whereas it might be a very easy one. To obviate this inconvenience, I propose that the angle of the slope of all broken normals should be exhibited, by

continuing the broken normals by a dotted line to the full length required to explain their nature; the features of the ground ceasing at the termination of the line part of the broken normal. Figure 2, in Plate No. 3, will explain at one view my meaning. The two lowest normals in that figure are broken normals. The last but one, when measured with the addition of the dotted part, and referred to the normal scale, shows the slope to be at an angle of 11° , the same as the preceding normal in the series; but being drawn one half with a line, and one half dotted, we are aware that the slope ceases where the dotted part begins; and that it is only a half normal having a perpendicular of 11 feet instead of 22 feet, as will be made evident by referring to the section above it. The lowest normal is also a broken one, and appears, when measured, according to the

rule I have explained, to be three-fourths of a normal of 2° . It will be observed that this normal commences at the termination of the line part of the preceding normal. The dotted ends of the broken normals are to be no further considered, and are meant to be of no further use than to indicate the value of the broken normal to which they severally belong, by being measured with them to make up their respective lengths.

XXXIV.—To my excellent and respected friend, Colonel Van Gorkum, ample apologies are due for the very great liberties I have taken with his system. His plans are, as I have before observed, perfect, and are almost as good as models of the ground. Any attempt, however, to introduce his system in all its details into our service would, I am fully convinced,

be nugatory. I have therefore selected what appeared to me most useful, and what can easily be adopted and engrafted upon our present mode. Having laid down as a fixed principle, that no normal should be less than the tenth of an inch, I was obliged to alter his perpendicular, and to have my scale constructed accordingly. I have not recommended the adoption of the horizontal sections or concentric figures he employs, on account of the reasons assigned in the early part of this memoir, in paragraphs V. and X.; and, proposing only to project the normals occasionally, and not over the whole plan, as in his method, I was obliged to think of some other mode with regard to broken normals, not being able to show their nature, as he does, by their contiguity. Whether, however, we may hereafter adopt in our more finished surveys, the whole of

Colonel Van Gorkum's plan, or content ourselves with the simple and easily acquired improvements I have suggested, it is to the ingenuity and talents of that officer we owe the happy idea of augmenting the perpendicular, which one step alone rendered the normal system practically useful.

XXXV.—I have now, I believe, afforded every explanation, and given every detail which can be required, for the introduction of the system into his Majesty's service. The necessity of any thing further being added may, consequently, not be immediately evident. I cannot, however, lay down my pen without expressing the very great satisfaction I feel at having been fortunately enabled, by circumstances, to be the channel by which so great an improvement in military topography is

communicated to the British army. The truth of the normal system is indeed so evident, and its application to practical purposes so easy, that the only wonder is, it was not long ago discovered and made use of. We may say of it, as Columbus remarked in reply to those who saw nothing wonderful in his breaking his egg to make it stand on the table, " It is nothing extraordinary, but none of you thought of it before." By the projection of a few normals our plans may hereafter be not only legible, but demonstratively so. At present they are like the ancient Egyptian hieroglyphics, conveying but vague and undefined notions, instead of that positive and distinct information we require.

JAMES CARMICHAEL-SMYTH,
Major General.

NUTWOOD, REIGATE,
March 25, 1828.

*E of the PERPEN different Scales; the PERPENDICULAR
Inch, and progre whenever necessary, so as to allow no
he tenth of an I*

Mile.	At	At One Inch to a Mile.			Remarks
Hypothenus	Perpendi	Perpendicular	Normal	Hypothenus	
1260·3	33	132	7562·3	7563·4	$\frac{1}{10}$ th of an Inch
630·4	do.	do.	3780	3782·3	
420·4	do.	do.	2518·7	2522·2	
315·4	do.	do.	1887·7	1892·3	
252·4	do.	do.	1508·8	1514·5	
210·4	do.	do.	1255·9	1262·8	
180·5	do.	do.	1075·1	1083·1	
158	do.	do.	939·2	948·5	
140·6	do.	do.	833·4	843·8	
126·7	do.	do.	748·6	760·1	
115·3	do.	do.	679	691·7	$\frac{2}{10}$ ths
105·8	do.	do.	621	634·8	
195·2	66	264	1143·5	1173·6	
181·8	do.	do.	1058·9	1091·3	
166·1	do.	do.	985·2	1020	
159·6	do.	do.	920·6	957·7	
150·8	do.	do.	863·5	902·9	
142·3	do.	do.	812·5	854·3	
135·2	do.	do.	766·7	810·8	
128·7	do.	do.	725·3	771·8	
122·8	do.	do.	687·7	736·6	$\frac{3}{10}$ ths
117·4	do.	do.	653·4	704·7	
112·6	do.	do.	621·9	675·6	
108·2	do.	do.	592·9	649	
104·1	do.	do.	566·1	624·6	$\frac{4}{10}$ ths
150·5	99	396	811·9	903·3	
145·3	do.	do.	777·1	872·2	
140·6	do.	do.	744·8	843·5	
136·7	do.	do.	714·4	816·8	$\frac{5}{10}$ ths
132	do.	do.	685·8	792·8	
112·7	do.	do.	565·5	690·4	$\frac{6}{10}$ ths
136·9	132	528	629·2	821·4	
124·4	do.	do.	528	746·7	$\frac{7}{10}$ ths
143·6	165	660	553·8	861·5	
134·3	do.	do.	462·1	805·7	
152·4	198	792	457·2	914·5	
145·6	do.	do.	369·3	873·8	
163·9	231	924	336·3	983·3	
155·8	do.	do.	247·5	956·6	

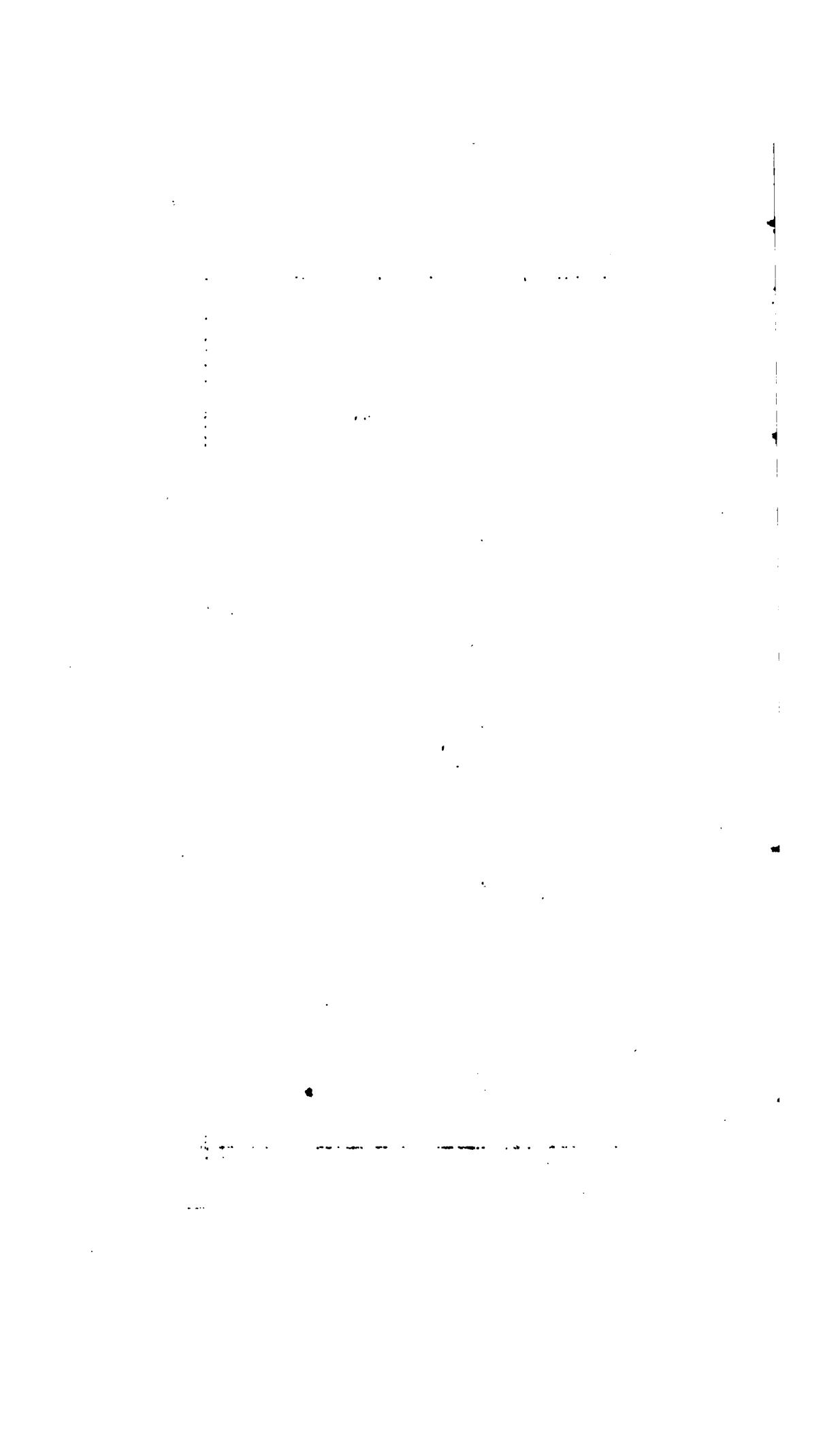
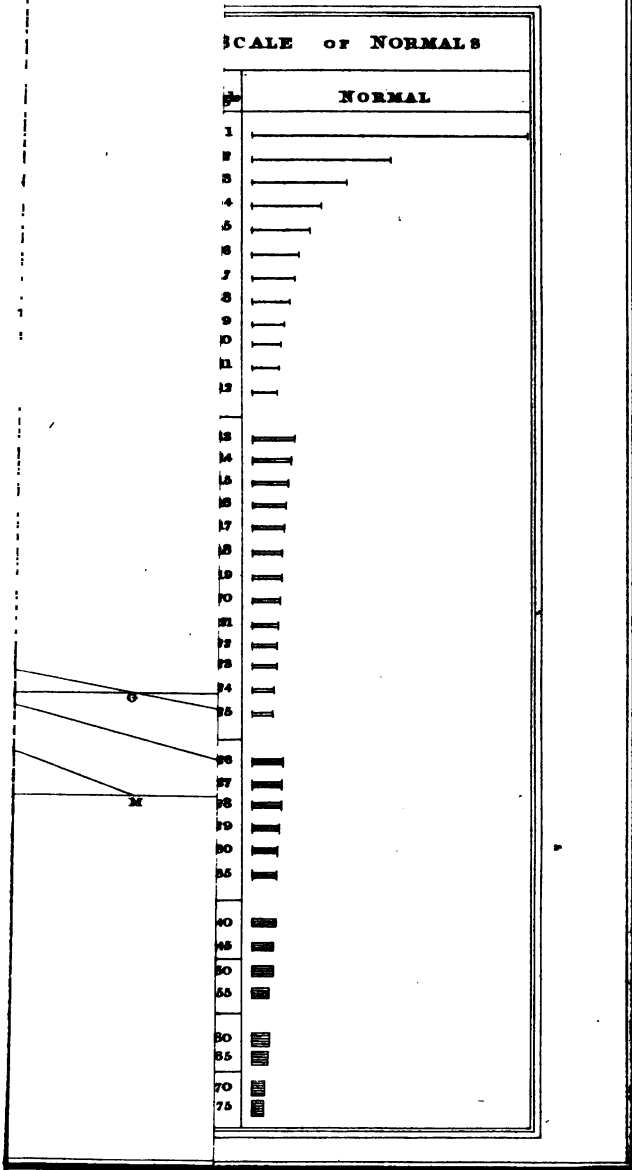


FIG. N° 2.



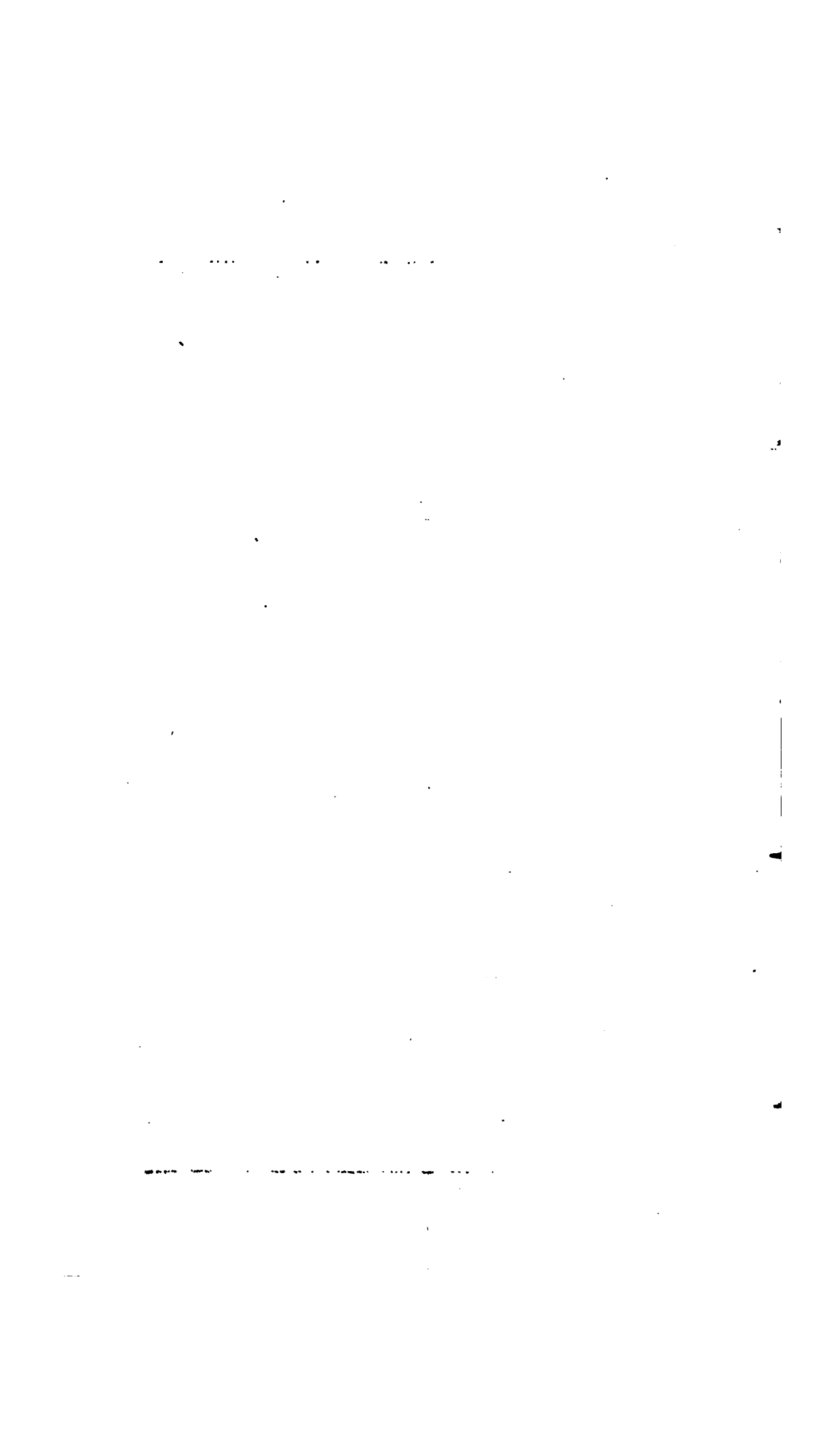


Fig 1.

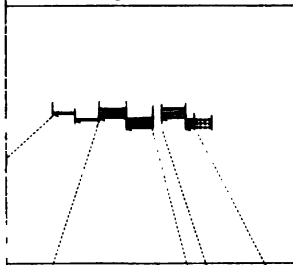
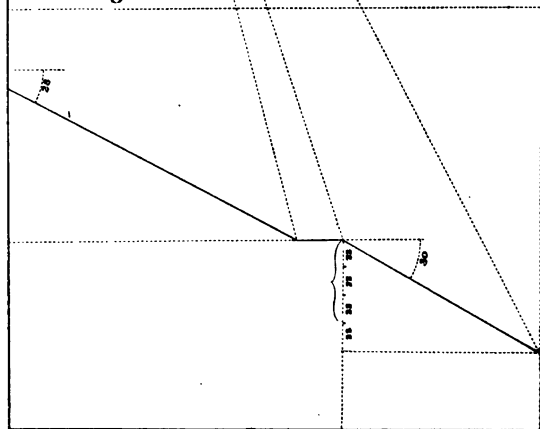


Fig 2.



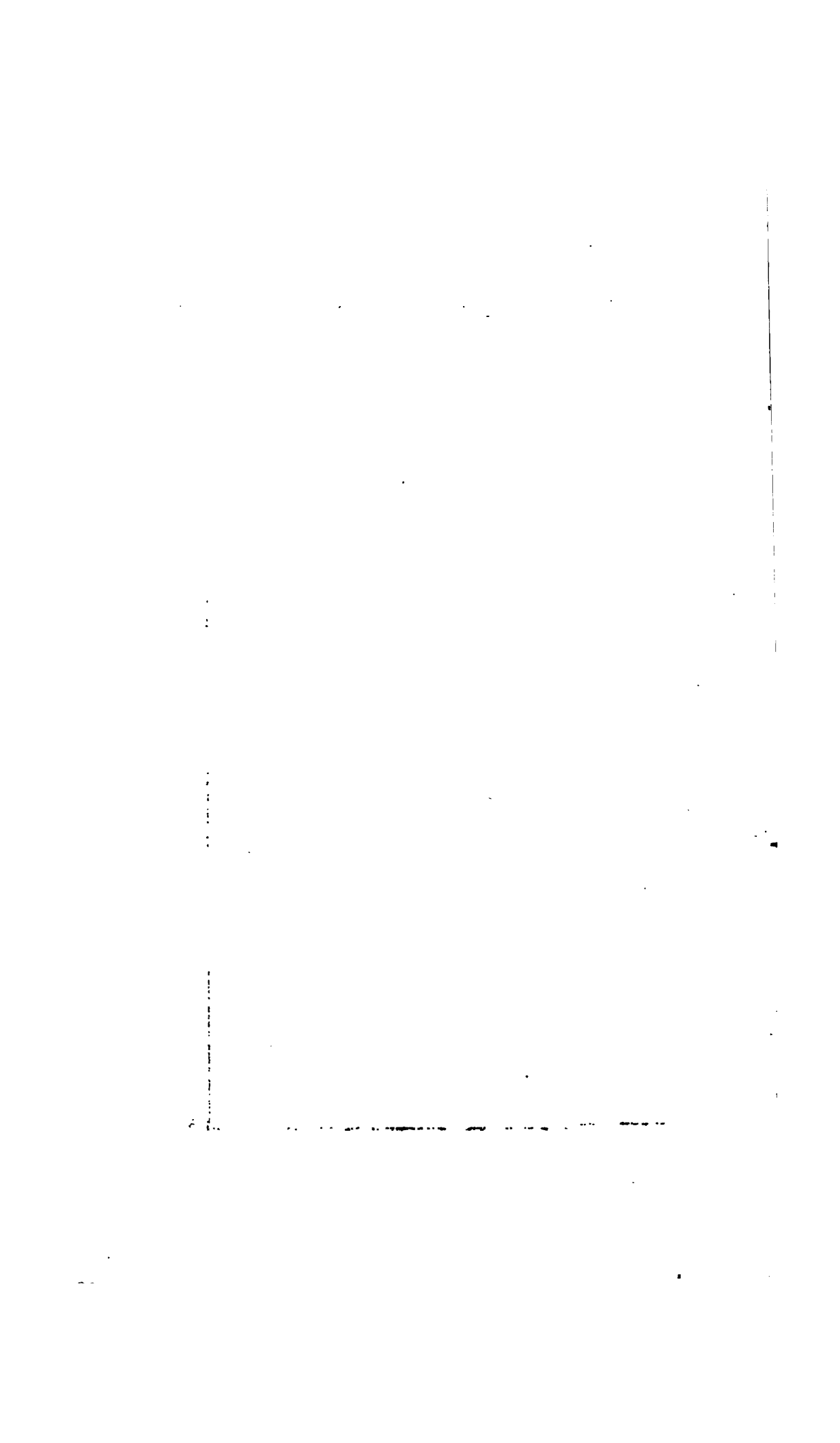
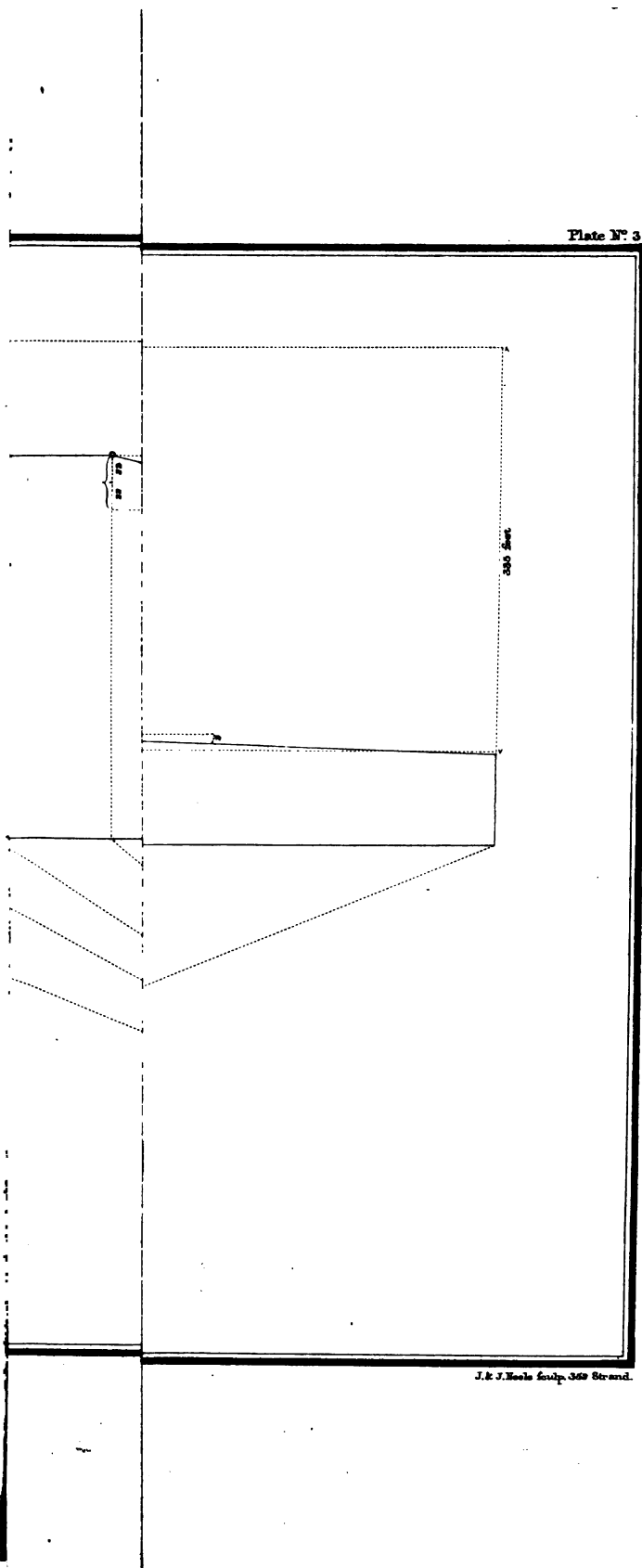
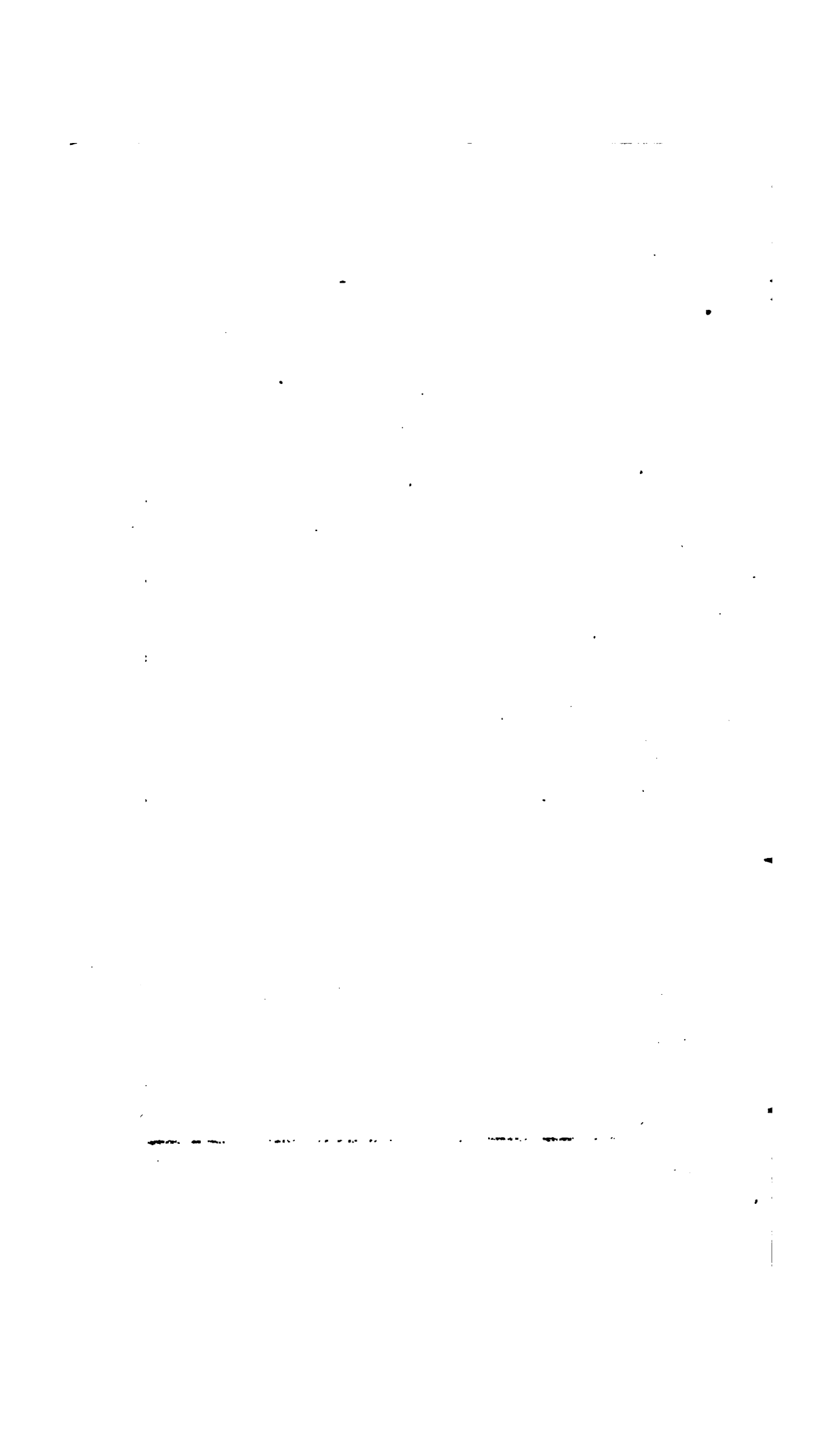
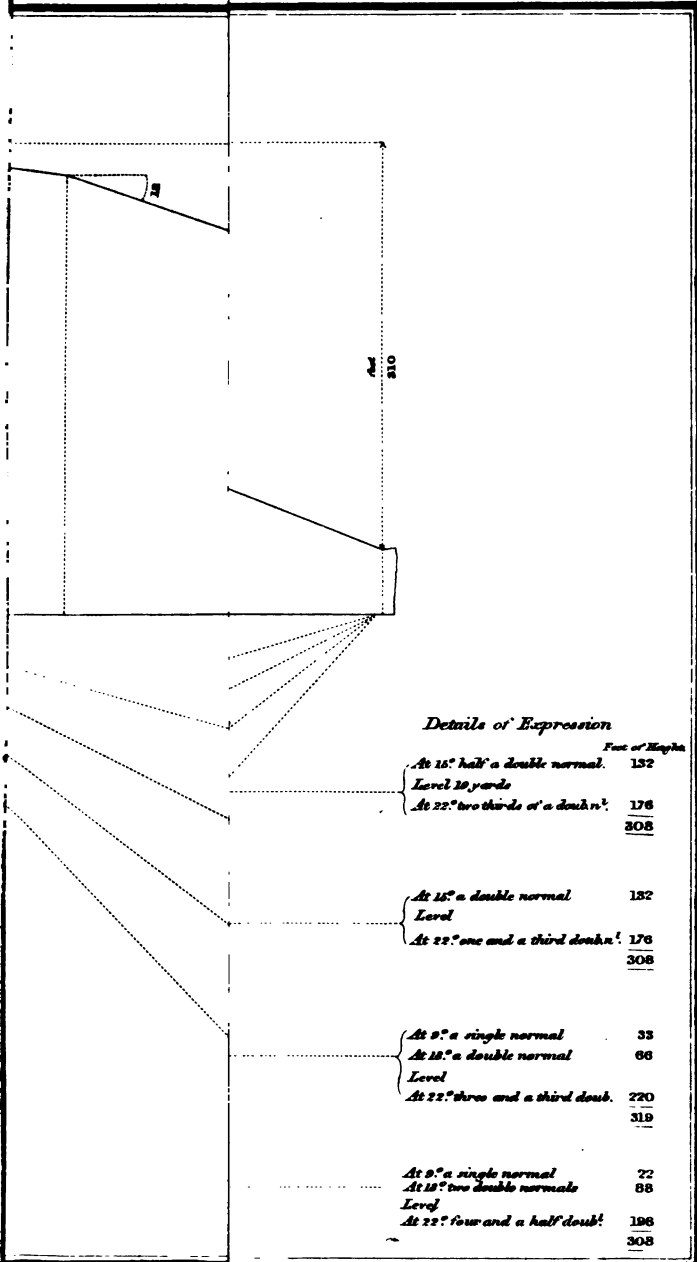
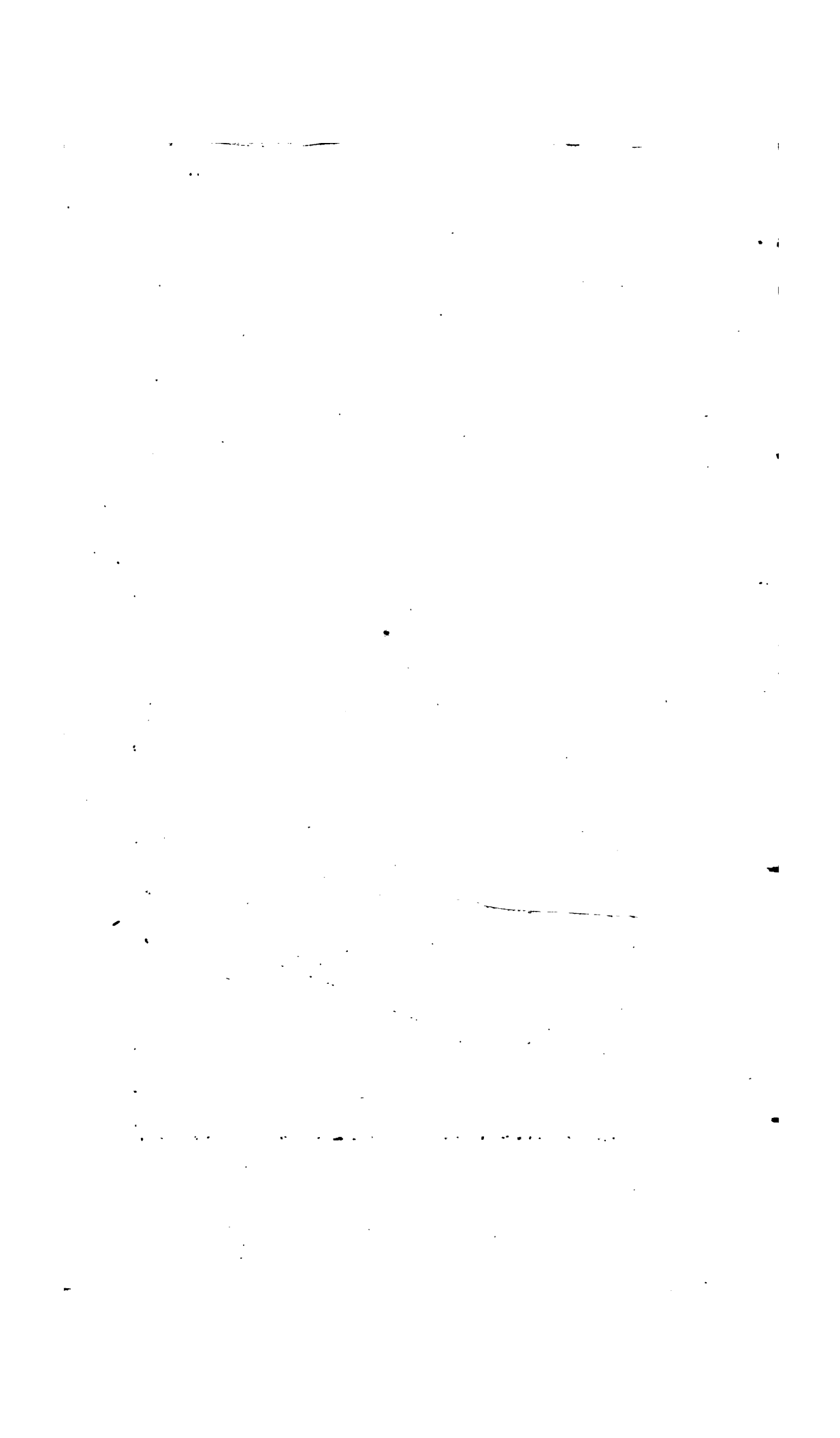


Plate N° 3.











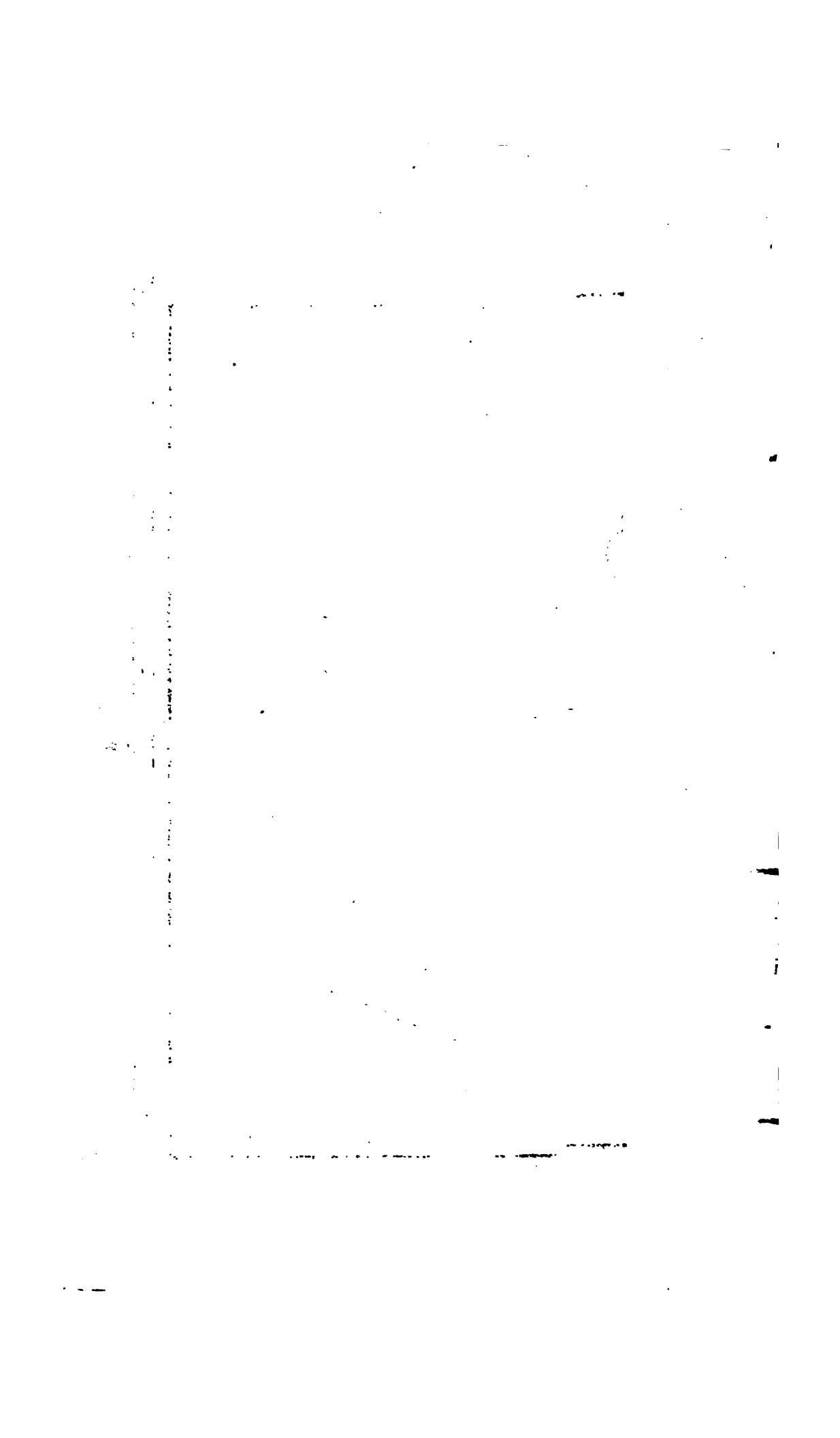
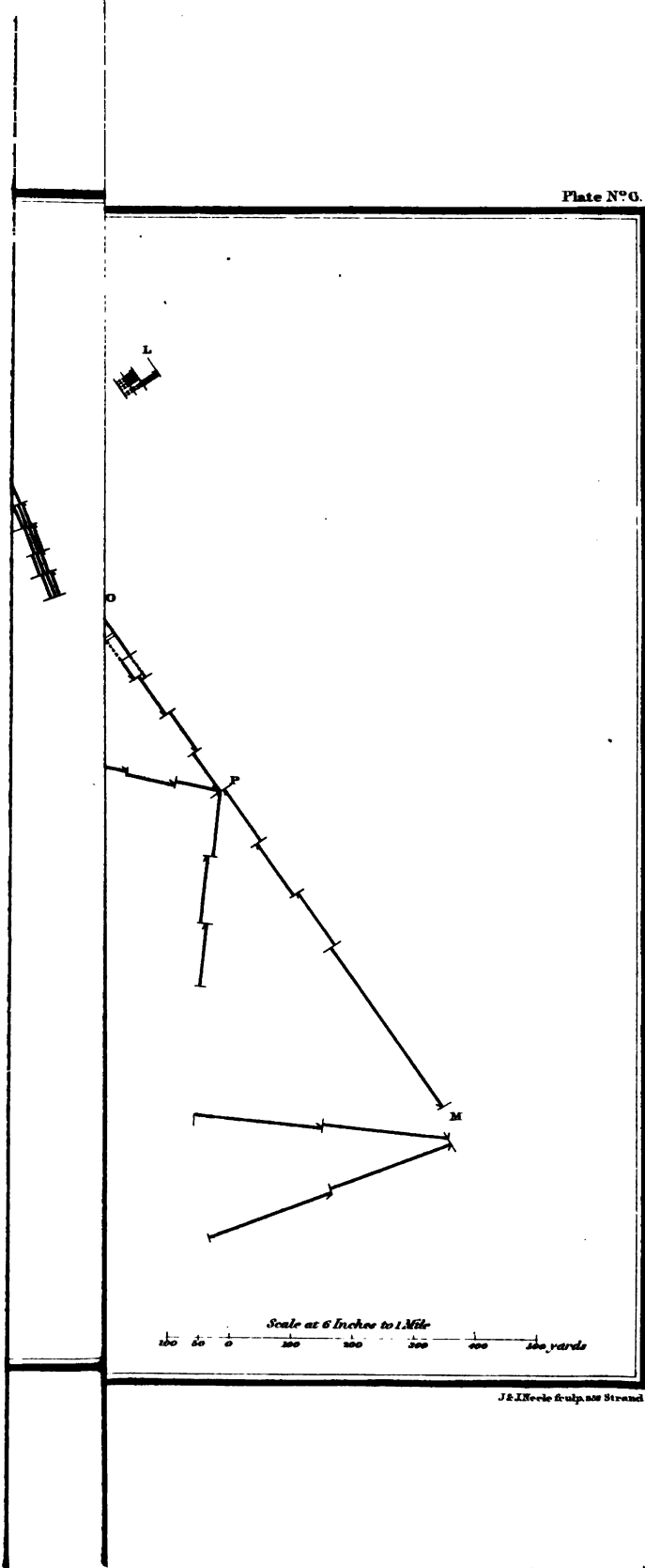


Plate N^o 6.



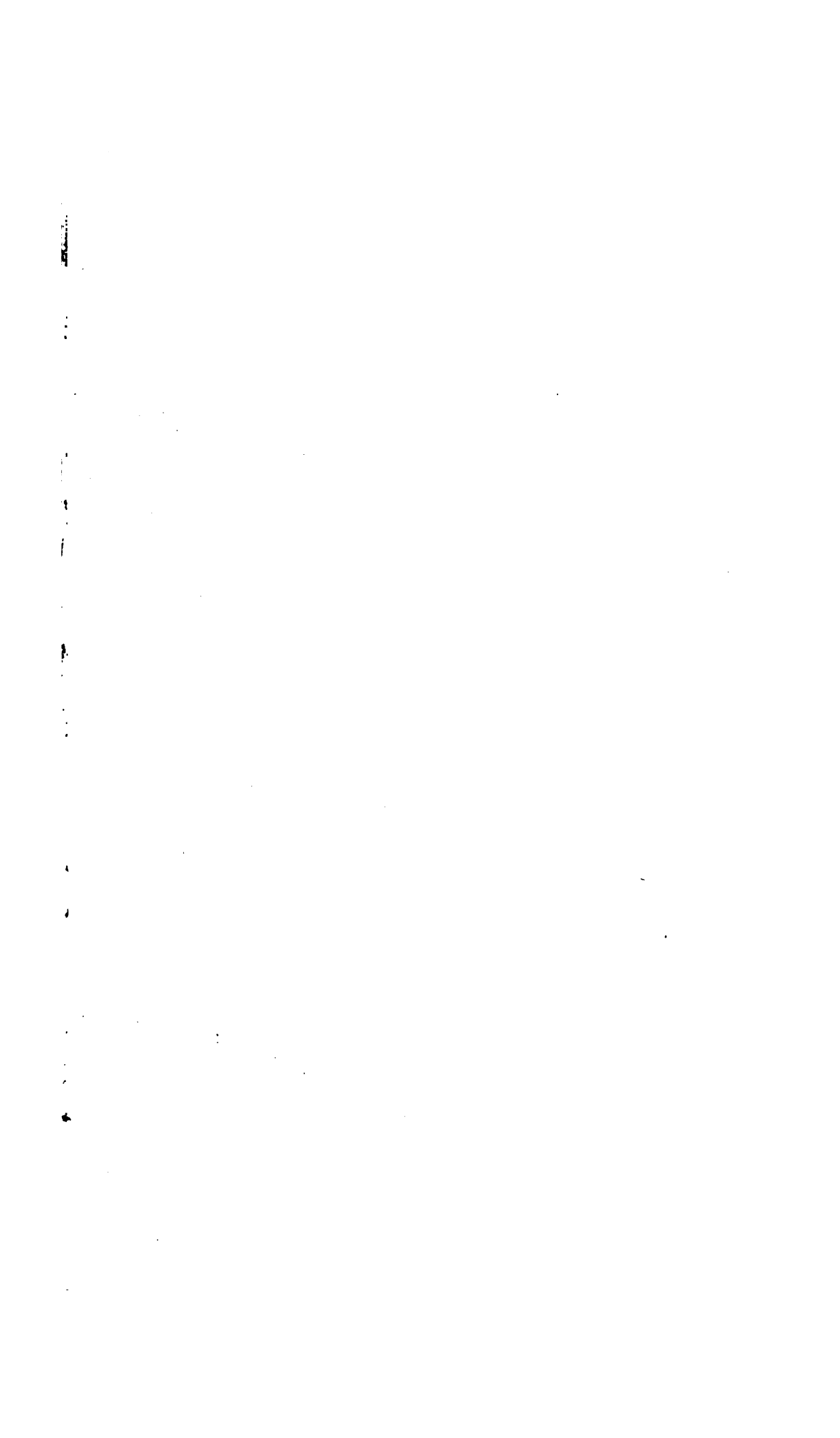
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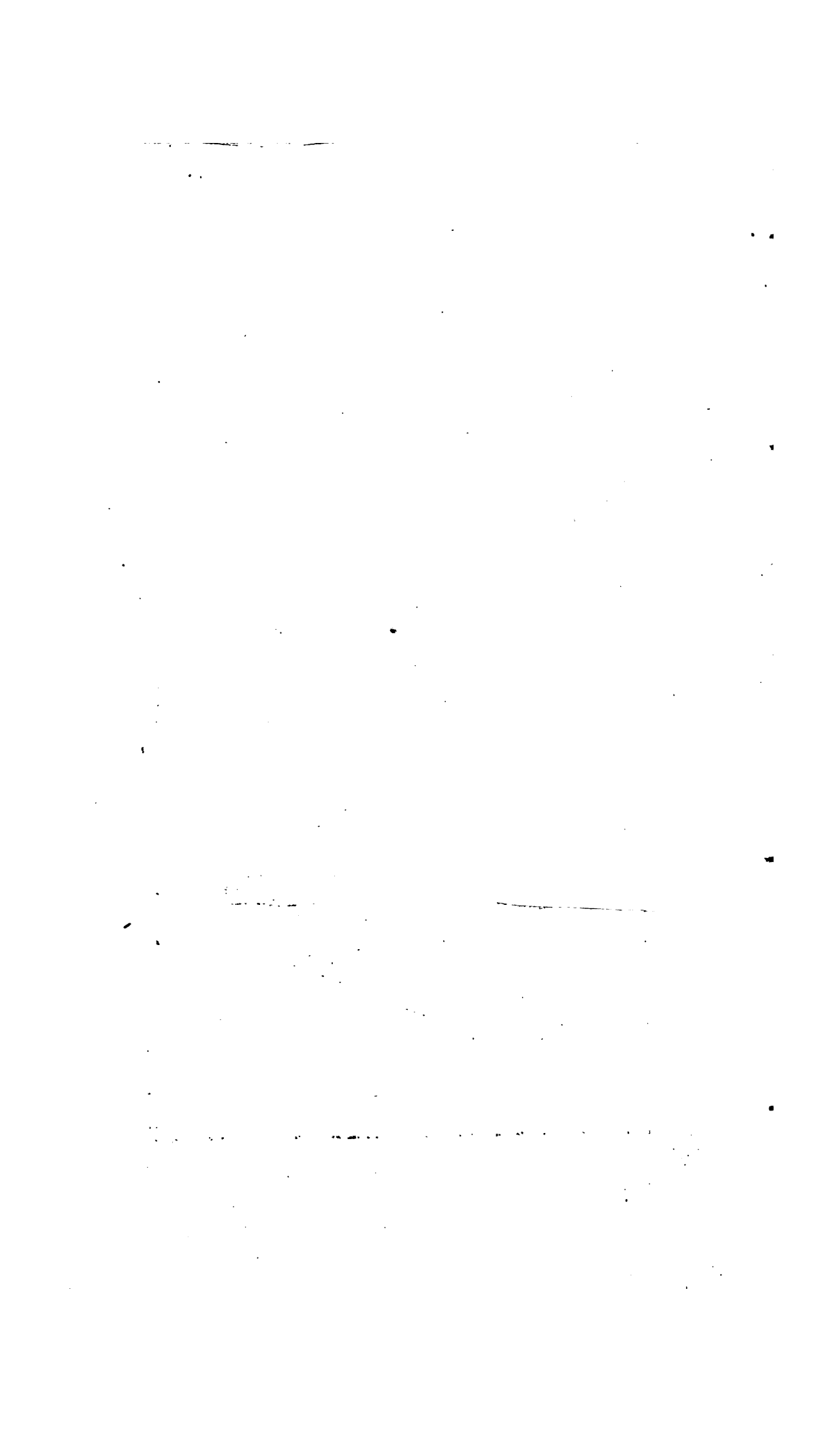


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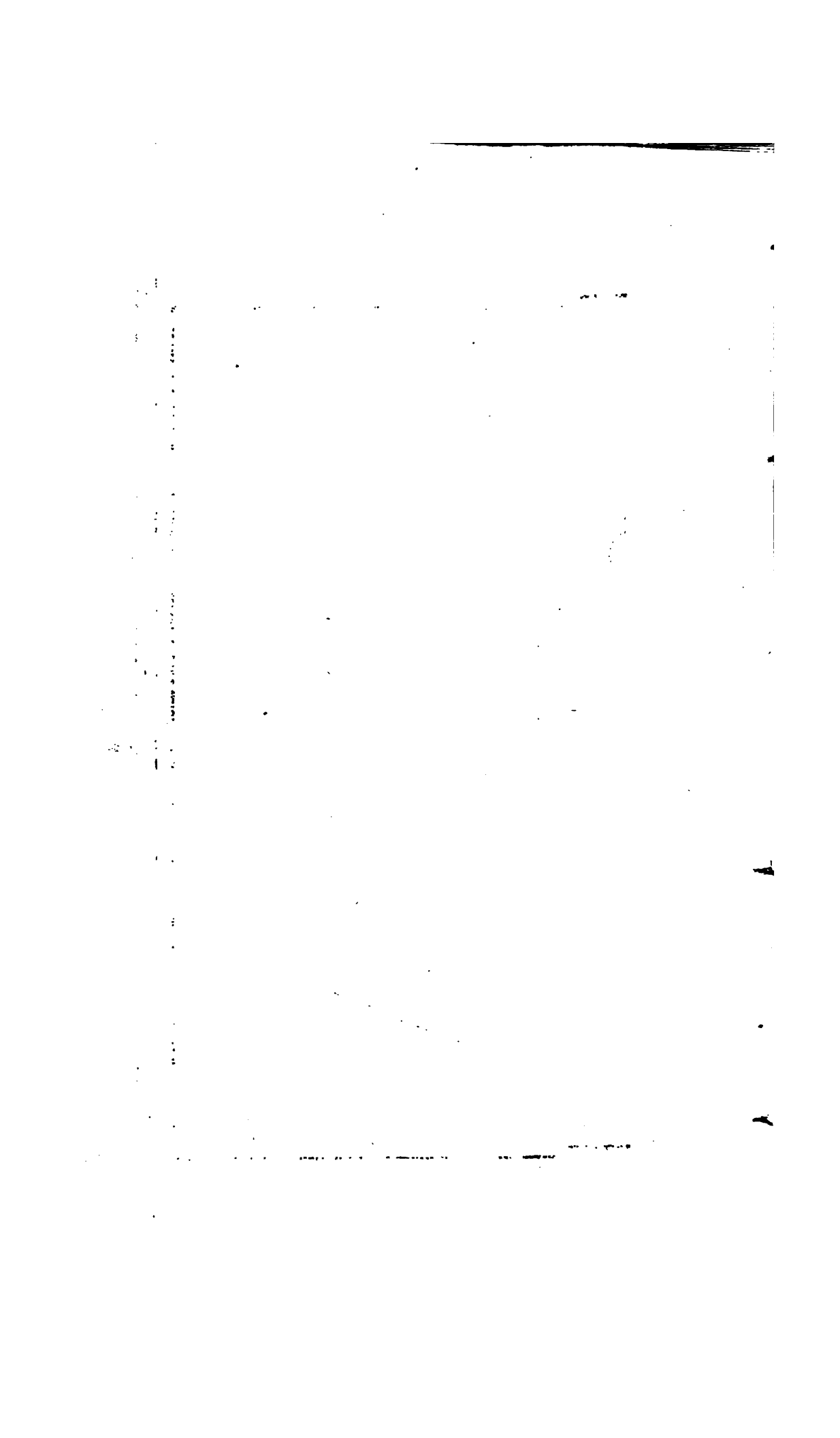
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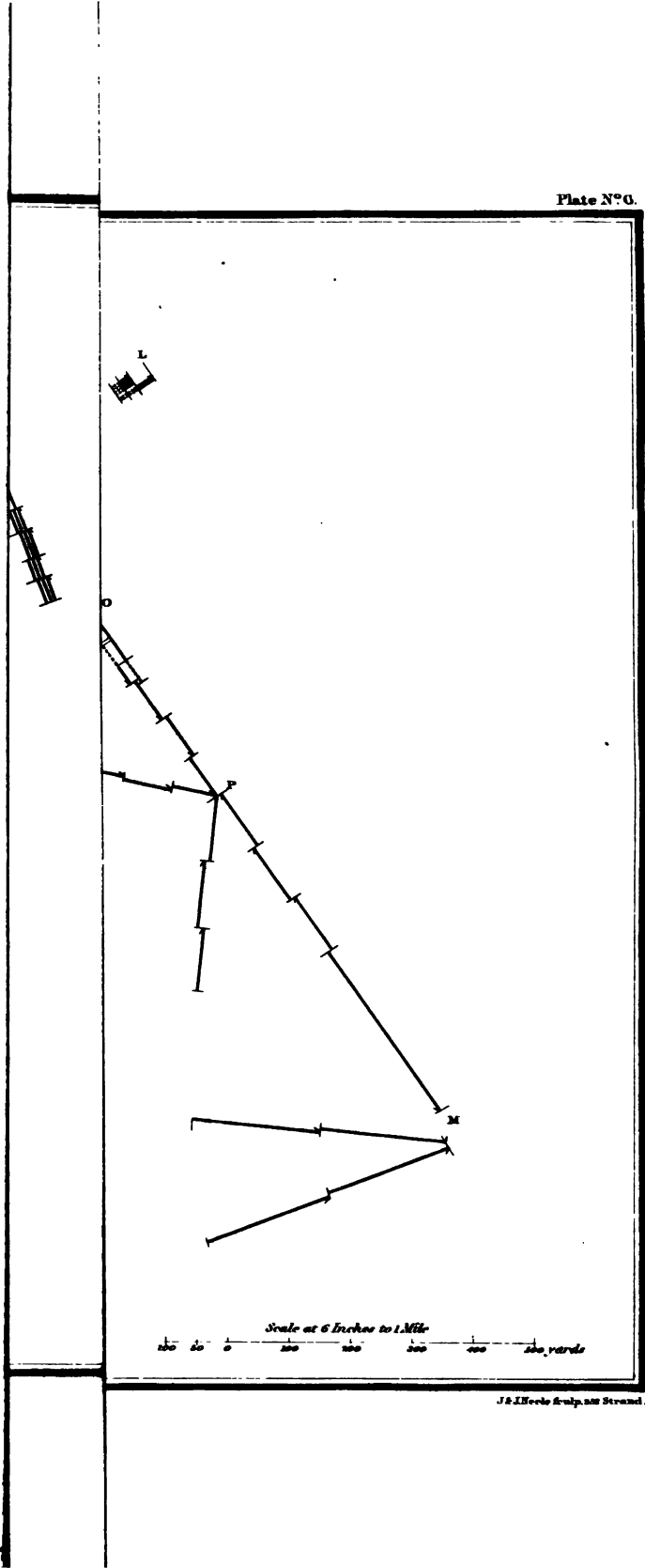
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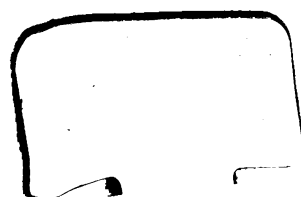








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